

REPORT DOCUMENTATION PAGE					Form Approved OMB No. 0704-0188	
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1. REPORT DATE (DD-MM-YYYY) 31-03-2017		2. REPORT TYPE Final		3. DATES COVERED (From - To)		
4. TITLE AND SUBTITLE Test Operations Procedure (TOP) 02-2-820 Tactical Vehicle Climate Control Testing				5a. CONTRACT NUMBER		
				5b. GRANT NUMBER		
				5c. PROGRAM ELEMENT NUMBER		
6. AUTHORS				5d. PROJECT NUMBER		
				5e. TASK NUMBER		
				5f. WORK UNIT NUMBER		
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) U.S. Army Aberdeen Test Center ATTN: TEDT-AT-ADI 400 Collieran Road Aberdeen Proving Ground, MD 21005-5059				8. PERFORMING ORGANIZATION REPORT NUMBER TOP 02-2-820		
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) Policy and Standardization Division (CSTE-TM) U.S. Army Test and Evaluation Command 2202 Aberdeen Boulevard Aberdeen Proving Ground, MD 21005-5001				10. SPONSOR/MONITOR'S ACRONYM(S)		
				11. SPONSOR/MONITOR'S REPORT NUMBER(S) Same as item 8		
12. DISTRIBUTION/AVAILABILITY STATEMENT  Distribution Statement A. Approved for public release; distribution is unlimited.						
13. SUPPLEMENTARY NOTES Defense Technical Information Center (DTIC), AD No.:						
14. ABSTRACT  This Test Operations Procedure (TOP) provides procedures for determining the maximum performance climate control capability of tactical vehicles in a minimalist baseline configuration inside of a climactic test chamber.						
15. SUBJECT TERMS Arctic tests, low temperature, high temperature, defroster, air-conditioning, desert tests, heaters, vehicles, tactical, wheeled						
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT  SAR	18. NUMBER OF PAGES 27	19a. NAME OF RESPONSIBLE PERSON	
a. REPORT Unclassified	b. ABSTRACT Unclassified	c. THIS PAGE Unclassified			19b. TELEPHONE NUMBER (include area code)	

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US ARMY TEST AND EVALUATION COMMAND  
TEST OPERATIONS PROCEDURE

\*Test Operations Procedure 02-2-820  
DTIC AD No.

31 March 2017

TACTICAL VEHICLE CLIMATE CONTROL TESTING

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## 1. SCOPE.

This Test Operations Procedure (TOP) provides procedures for determining the maximum performance climate control capability of tactical vehicles in a minimalist baseline configuration inside of a climactic test chamber.

## 2. FACILITIES AND INSTRUMENTATION.

### 2.1 Facilities.

Chamber Climatic Tests. A temperature chamber large enough to accommodate the test vehicle that can maintain the following conditions throughout the entire test period:

- a. A temperature range from 49 ° to -46 °Celsius (°C) (120 ° to -50 °Fahrenheit (°F),  $\pm 3$  °C (5 °F).
- b. A maximum wind speed not exceeding 8 kilometers per hour (km/hr) (5 miles per hour (mph)).
- c. A solar load of 1120 watt per square meter ( $\text{W/m}^2$ )  $\pm 47 \text{ W/m}^2$ , that meets the spectral energy distribution per Military Standard (MIL-STD)-810G CN1<sup>1\*\*</sup>, for air-conditioning (A/C) testing only.

### 2.2 Instrumentation.

<u>Devices for Measuring</u>	<u>Maximum Error of Measurement<sup>a</sup></u>
Temperature	$\pm 0.6$ °C (1 °F)
Wet bulb temperature	$\pm 3$ °C (5 °F)
Relative humidity (RH)	$\pm 3$ percent of full scale
Total Irradiance	Second Class minimum, First Class recommended
Engine speed	$\pm 10$ revolutions per minute (rpm)
Air pressure (as appropriate)	$\pm 1$ pounds per square inch (psi)
Air speed	$\pm 0.8$ km/hr (0.5 mph)

<sup>a</sup> Values may be assumed to represent  $\pm 2$  standard deviations. Thus, the stated tolerances should not be exceeded in more than 1 measurement out of 20.

\*\* Superscript numbers correspond to Appendix C, References.

### 2.3 Additional Equipment.

A calibrated data logger is required to record the data during testing and soak periods. A digital camera is suggest to photograph all instrumentation locations. A tape measure, a graduated cylinder and an electric paint sprayer are required to determine the area of windshield, measure the correct amount of water and to apply the icing for defroster testing.

## 3. REQUIRED TEST CONDITIONS.

### 3.1 General Vehicle and Test Preparations.

a. Ensure that initial inspection and preliminary operation of the vehicle have been accomplished in accordance with TOP 02-2-505<sup>2</sup>. All cab dashboard components, firewall kick panels, and crew seats are to be correctly installed and secured. Testing should be conducted in the most basic minimalist configuration the test vehicle is provided. Document the mission configuration of the test vehicle, ensuring all basic issue items and mission package equipment are stowed in their proper locations.

b. For heater and defroster testing, prepare the test vehicle for cold-weather operation in accordance with the vehicle Technical Manual (TM) and Field Manual (FM) 9-207<sup>3</sup> (e.g., arctic antifreeze is installed in the cooling systems and arctic lubricating and gear oils installed in other systems as prescribed in the lubrication order for cold-weather operations). Component fluids should be drained and refilled with the appropriate lubricant specified in the TM and recorded. Ensure that the test vehicle is filled to sufficient levels with the appropriately specified fuel, and that fuel filters and fuel/water separators are replaced as required. Flushing of components is not recommended unless included in the TM procedures, as this is not normally performed in the field, however it may be necessary for fuel fired heaters to ensure proper operation during the test. Ensure the heater or defroster system is operational at ambient temperature and that all engine coolant valves to the heater core (if equipped) are opened.

c. For A/C testing, prepare the test vehicle for hot-weather operation in accordance with the vehicle TM, if required. The A/C system refrigerant level should be verified by using an A/C refrigerant recovery machine to completely evacuate the system and recharge it to the correct amount specified in the vehicle's TM and recorded. Ensure the A/C system is operational at ambient temperature and that all engine coolant valves to the heater core (if equipped) are closed.

d. Ensure all other items that are not part of the vehicle inventory that could affect its performance during climate control system testing are removed, such as blocked opened thermostats. This includes apparatus from other testing that alter the volume and/or mass inside of the cab: sandbags, steel plate weights, water-dummies, etc.

### 3.2 Climate Control Systems.

- a. Inspect the vents and other external components for equipment discrepancies, damage, or missing parts. If damage has been sustained, obtain authorization and make repairs prior to testing.
- b. Check that all switches fully engage and reset, that all levers operate throughout their full range of motion without sticking or binding, and that all knobs are tight with their indicators correctly indexed. Loose knobs could potentially spin freely without engaging the underlying control which could result in the knob indicating a condition that does not correctly represent the actual position of the control.
- c. Prior to conditioning the test item, operate the climate control systems at ambient temperature to ensure that it functions normally. Ensure that all vents are connected to the climate control system and that airflow is present at each vent location.

### 3.3 Temperature Chamber.

- a. Position the vehicle in the test chamber so that:
  - (1) Air circulation is not impaired.
  - (2) Critical vehicle elements are accessible for inspection and operation.
  - (3) Clear and easy access is provided to personnel operation areas.
  - (4) Where possible, personnel can be seen through the chamber observation windows.
- b. Install ducts to remove vehicle, engine heater, and crew heater exhaust fumes from the chamber, as shown in Figure 1. Fabricate adapters (larger diameter exit) in order to prevent excessive exhaust restriction.

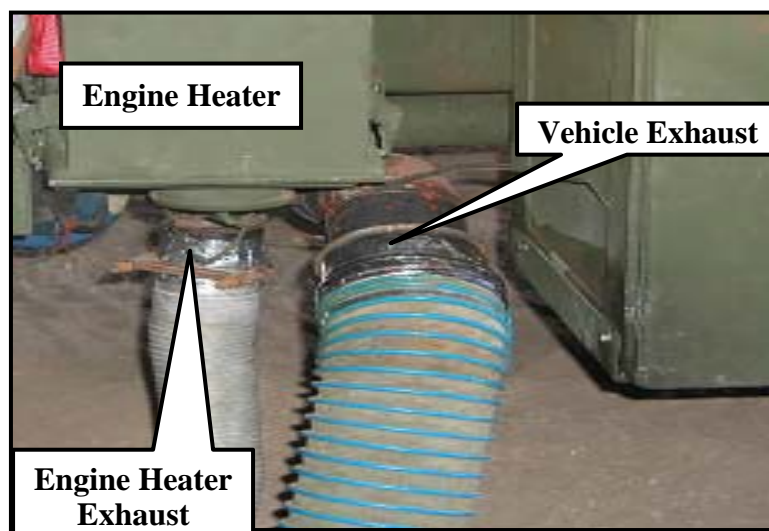


Figure 1. Set-up of ducts to remove fumes from a test chamber.

c. All necessary safety precautions such as video cameras, 2-way voice communications, and carbon monoxide monitoring devices in the climatic chamber are recommended.

### 3.4 Test Controls.

a. Do not continue testing when there is a large change in chamber air temperature. Temperature variation during the test should be kept to a minimum to ensure consistency and accuracy of results. It is desirable to keep temperature fluctuations within  $\pm 3^{\circ}\text{C}$  ( $5^{\circ}\text{F}$ ) of the target test temperature, per MIL-STD-810G CN1. The greatest care must be taken to monitor this parameter during periods where the vehicle engine is running while in the chamber. If temperature changes by more than  $\pm 5^{\circ}\text{C}$  ( $9^{\circ}\text{F}$ ) during test, repeat the test.

b. Do not activate or operate any of the test vehicle's auxiliary subsystems or mission package equipment, other than what is required to start the vehicle and climate control system, until after the test period has concluded, unless specifically instructed to do so in the vehicle performance specification.

## 4. TEST PROCEDURES.

### 4.1 Air-Conditioner Performance Test.

#### 4.1.1 Installation of Instrumentation.

a. Install instrumentation as described in Table 1, without significantly reducing the volume of, nor increasing the mass within, the crew compartment. The temperature recording locations for seating positions are depicted in Figure 2. These locations are measured from the Seat Reference Point (SRP), located at the center of the seat where the backrest meets the seat.

TABLE 1. A/C PERFORMANCE TEST RECOMMENDED INSTRUMENTATION

INSTRUMENTATION CHANNELS	UNIT OF MEASUREMENT
Chamber Ambient Control	$^{\circ}\text{C}$ ( $^{\circ}\text{F}$ )
Head, Hands and Feet Positions of Driver Seat	$^{\circ}\text{C}$ ( $^{\circ}\text{F}$ )
Head, Hands and Feet Positions of Passenger Seat	$^{\circ}\text{C}$ ( $^{\circ}\text{F}$ )
Head, Hands and Feet Positions of Rear Roadside Seat (if applicable)	$^{\circ}\text{C}$ ( $^{\circ}\text{F}$ )
Head, Hands and Feet Positions of Rear Curbside Seat (if applicable)	$^{\circ}\text{C}$ ( $^{\circ}\text{F}$ )
Head, Hands and Feet Positions of Other Occupant Seats (as applicable)	$^{\circ}\text{C}$ ( $^{\circ}\text{F}$ )

TABLE 1. CONTINUED

INSTRUMENTATION CHANNELS	UNIT OF MEASUREMENT
A/C Vents	°C (°F)
Compartment Enclosure Wet Bulb	°C (°F)
Chamber Humidity	% RH
Interior Cab Humidity	% RH
Engine Speed	rpm
Radiant Energy on Hood	W/m <sup>2</sup>
Radiant Energy on Roof	W/m <sup>2</sup>
A/C Discharge Pressure	pounds per square inch gauge (psig)
A/C Suction Pressure	psig

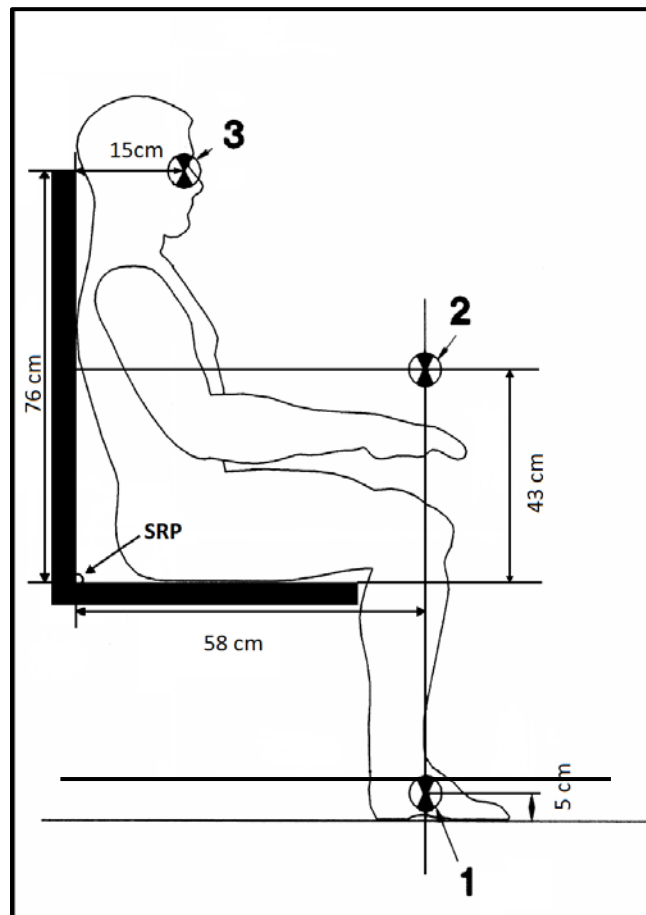


Figure 2. Temperature measurement locations for seating positions. Position 1 indicates the feet, Position 2 indicates the hands, and Position 3 indicates the head.



b. It is recommended that a pre-measured seating position fixture be designed for ease, accuracy and repeatability of recording these temperature locations, such as the example in depicted in Figure 3. This fixture was fabricated with polyvinyl chloride (PVC) pipe and the unglued joints provide enough friction to remain in position during testing, while being flexible enough to conform to various seating size and space constraints.

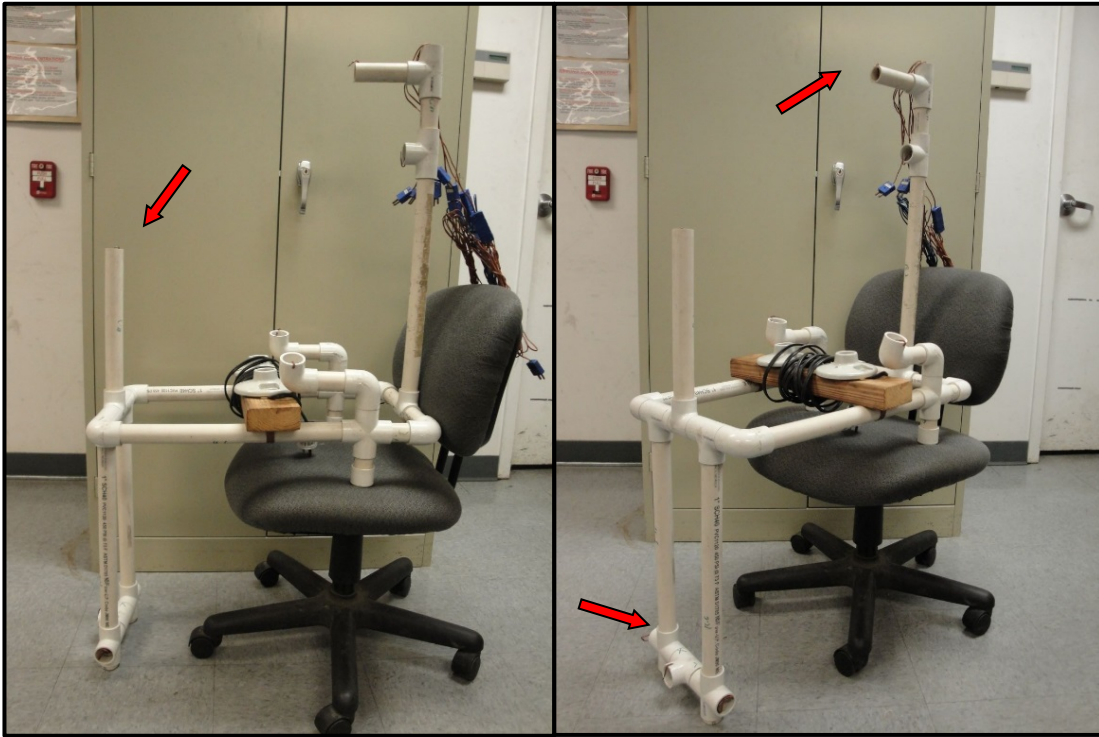


Figure 3. Seating position fixture with fixed distance head, hands, and feet temperature measurement locations.

c. Install one pyranometer on the center of the hood (where the compressor and condenser are typically located) and one on the center of the roof of the cab as depicted in Figure 4. Install two pyranometers centered on the roof if the vehicle cab length exceeds 2.4 m (8 ft), or the gunner turret protection or other roof mounted equipment does not make placement of a single pyranometer feasible.

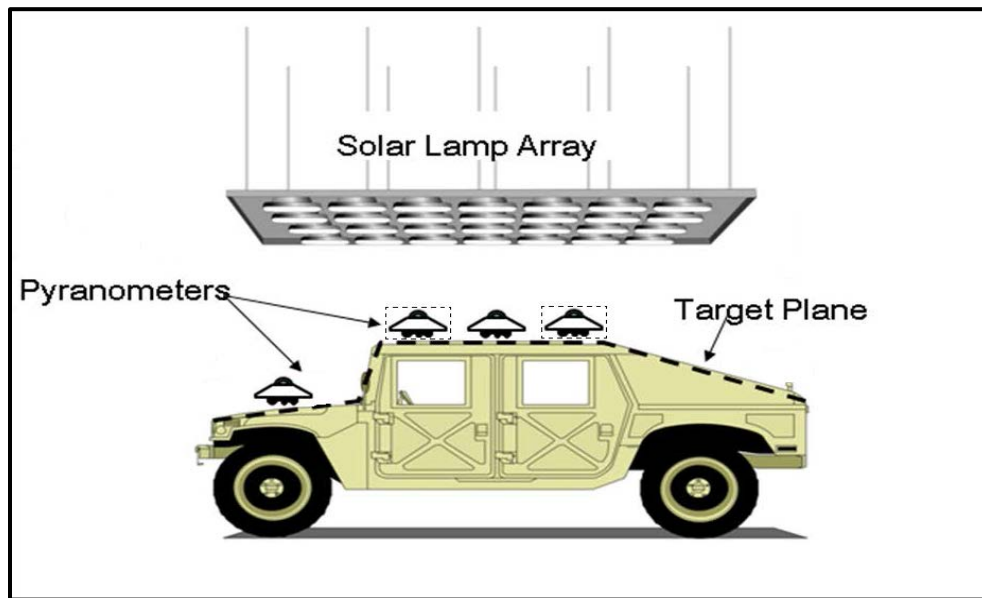


Figure 4. Pyranometer placement; pyranometers with dotted outline depict alternative placement when two pyranometers are used on the roof.

d. It is recommended that the instrumentation cables be routed out of the test vehicle through a small opening that can be sealed, such as a drain plug, wire pass-through, or the gunner's hatch that can remain closed throughout testing to prevent damaging the cables. Avoid running cables through doors and windows if possible.

e. Set all A/C vents to their fully open position, with the louvers facing perpendicular to the vent surface so that the airflow is unrestricted and not diverted to specifically point at any personnel location; no other louver direction may be used.

#### 4.1.2 Method.

a. Condition the test chamber to 49 °C (120 °F), unless an alternative temperature is stipulated in the vehicle performance specification, with all vehicle doors, hatches, ramps and the hood opened. Soak the vehicle for a minimum of 2 hours after all sensors have stabilized to within  $\pm 2$  °C ( $\pm 3.6$  °F) of the test temperature to satisfy the high temperature requirement of MIL-STD-810G CN1 for worldwide deployment.

b. Upon completion of the temperature soak period, close all doors, hatches, ramps, and the hood. Activate the simulated solar load lamp bank and adjust its output to attain the radiant energy test condition of  $1120 \text{ W/m}^2$  ( $\pm 47 \text{ W/m}^2$ ) with an irradiance uniformity of  $\pm 112 \text{ W/m}^2$  if 2 or more locations are measured on the test vehicle. Apply the solar loading for a minimum of 1 hour prior to conducting the A/C test and maintain this setting throughout the duration of the test period. Ensure solar load does not increase the chamber ambient temperature beyond test tolerances.

c. Upon completion of the solar soak period, start the vehicle's engine in accordance with the appropriate TMs and manufacturer-provided procedures. If the engine fails to start on vehicle battery power, connect a regulated 24-volt power source to the slave adapter for additional start attempts.

d. Once the vehicle engine has started, activate the A/C system within one minute. Set the A/C system controls according to the instructions in the TM to provide maximum cooling performance. If the TM does not provide adequate detail, set the controls in accordance with the recommendations in Table 2

TABLE 2. CLIMATE CONTROL SETTINGS FOR A/C PERFORMANCE TEST

CONTROL	SETTING
A/C Power	On
Climate Control System Mode	Cooling, A/C
Temperature Control Setting	Full Cold (blue)
Output Vent Selector	Upper Main Vents
Fan Speed	Maximum
Source Air Selector	Recirculation

**NOTE:** If the vehicle is equipped with a secondary A/C system, set the controls in the same manner and activate it immediately after the main system.

e. Engage the vehicle's high idle or tactical idle, as soon as allowable by the TM, and maintain this setting for the entire test period. The operator is to then exit the vehicle and close the door, no personnel are to occupy the crew compartment during testing (an operator presence would affect the volume and mass inside of the cab, potentially alter air flow paths and distribution, in addition to introducing uncontrolled amounts of water vapor through respiration and perspiration, altering the relative humidity). The vehicle doors will not be opened until the test period is completed. Any test interruptions or deviations from this procedure are to be documented.

**NOTE:** If the vehicle is not equipped with a high idle or tactical idle setting, conduct the A/C performance test at normal engine idle speed. If the vehicle is equipped with a system that automatically increases the engine speed when the A/C is activated do not engage any other tactical idle or high idle setting manually.

f. Operate the A/C system for one hour, compute the average temperature at each of the three measurement locations (head, hands, feet) for each instrumented seating position. The required average temperature at each instrumented seating position must be 29.5 °C (85 °F) or lower. Additionally, the maximum difference allowed between the head, hands and feet temperatures at each respective seating position, shall not exceed 5.5 °C (10 °F).

g. Data results indicate maximum A/C system performance in the test vehicle's provided configuration, with an unoccupied cab, and without operating any auxiliary subsystems or mission package equipment.

#### 4.2 Heater Performance Test.

##### 4.2.1 Installation of Instrumentation.

a. Install instrumentation as described in Table 3, without significantly reducing the volume of, nor increasing the mass within, the crew compartment. The temperature recording locations for seating positions are depicted in Figure 2. These locations are measured from the SRP, located at the center of the seat where the backrest meets the seat.

TABLE 3. HEATER TEST RECOMMENDED INSTRUMENTATION

INSTRUMENTATION CHANNELS	UNIT OF MEASUREMENT
Chamber Ambient Control	°C (°F)
Head, Hands and Feet Positions of Driver Seat	°C (°F)
Head, Hands and Feet Positions of Passenger Seat	°C (°F)
Head, Hands and Feet Positions of Rear Roadside Seat (if applicable)	°C (°F)
Head, Hands and Feet Positions of Rear Curbside Seat (if applicable)	°C (°F)
Head, Hands and Feet Positions of Other Occupant Seats (as applicable)	°C (°F)
Heater Vents	°C (°F)
Engine Coolant	°C (°F)
Engine Speed	rpm

b. It is recommended that a pre-measured seating position fixture be designed for ease, accuracy and repeatability of recording these temperature locations, such as the example in depicted in Figure 3. This fixture was fabricated with PVC pipe and the unglued joints provide enough friction to remain in position during testing, while being flexible enough to conform to various seating size and space constraints.

c. It is recommended that the instrumentation cables be routed out of the test vehicle through a small opening that can be sealed, such as a drain plug, wire pass-through, or the gunner's hatch, that can remain closed throughout testing to prevent damaging the cables. Avoid running cables through doors and windows if possible.

d. Set all heater vents to their fully open position, with the louvers facing perpendicular to the vent surface so that the airflow is unrestricted and not diverted to specifically point at any personnel location; no other louver direction may be used.

#### 4.2.2 Method.

a. Condition the test chamber to the desired test temperature, -32 °C (-25 °F) (to meet the low temperature operations of climactic design type Basic Cold (C1)), or -46 °C (-50 °F) (to meet the low temperature operations of climactic design type Cold (C2)), unless alternative temperatures are stipulated in the vehicle performance specification, with all vehicle doors, hatches, ramps and the hood opened. If a cold start test is to be performed prior to the heater test, soak the vehicle for a minimum of 8 hours after all components have stabilized to within 2 °C (3.6 °F) of the test temperature to satisfy the cold start requirement of TOP 02-2-650<sup>4</sup>. If a cold start test is not being performed prior to the heater test, continue to soak the vehicle for a minimum of 2 hours after all temperature sensors have stabilized to within  $\pm 2$  °C ( $\pm 3.6$  °F) of the test temperature to satisfy the low temperature requirements of MIL-STD-810G CN1.

b. Upon completion of the temperature soak period, close all doors, hatches, ramps, and the hood. If a cold start test is to be performed prior to the heater test, start the vehicle's engine in accordance with TOP 02-2-650. If a cold start test is not being performed prior to the heater test, start the vehicle's engine in accordance with the appropriate TMs and manufacturer-provided procedures. If the engine fails to start on vehicle battery power, connect a regulated 24-volt power source to the slave adapter for additional start attempts.

c. Once the vehicle engine has started, activate the cab heater within one minute. Set the cab heater controls according to the instructions in the TM to provide maximum heating performance. If the TM does not provide adequate detail, set the controls in accordance with the recommendations in Table 4.

TABLE 4. CLIMATE CONTROL SETTINGS FOR HEATER PERFORMANCE TEST

CONTROL	SETTING
Cab Heater Power	On
Climate Control System Mode	Heating
Temperature Control Setting	Full Hot (red)
Output Vent Selector	Upper Main Vents
Fan Speed	Maximum
Source Air Selector	Recirculation

**NOTE:** If the vehicle is equipped with a secondary crew heater, set the controls in the same manner and activate it immediately after the main system. If the heater and defroster are on separate systems, such as the heater is fuel fired and defroster uses engine coolant, refer to the TM and vehicle performance specification for determination if it would be appropriate to activate the defroster during the heater test.

d. Engage the vehicle's high idle or tactical idle, as soon as allowable by the TM, and maintain this setting for the entire test period. The operator is to then exit the vehicle and close the door, no personnel are to occupy the crew compartment during testing (an operator presence would affect the volume and mass inside of the cab, potentially alter air flow paths and distribution, in addition to introducing uncontrolled amounts of water vapor through respiration and perspiration, altering the relative humidity). The vehicle doors will not be opened until the test period is completed. Any test interruptions or deviations from this procedure are to be documented.

**NOTE:** If the vehicle is not equipped with a high idle or tactical idle setting, conduct the heater performance test at normal engine idle speed. If the vehicle is equipped with a system that automatically increases the engine speed when the heater is activated do not engage any other tactical idle or high idle setting manually.

e. Operate the cab heater for one hour, compute the average temperature at each of the three measurement locations (head, hands, and feet) for each instrumented seating position. The required average temperature at each instrumented seating position must be 20 °C (68 °F) (5 °C (41 °F) if Arctic clothing is worn) or higher. Additionally, the maximum difference allowed between the head hands and feet temperatures at each respective seating position, shall not exceed 5.0 °C (9.0 °F). Both of these temperature specifications satisfy the requirements of MIL-STD-1472G<sup>5</sup>.

f. Data results indicate maximum heater system performance in the test vehicle's provided configuration, with an unoccupied cab, and without operating any auxiliary subsystems or mission package equipment.

#### 4.3 Defroster Test.

##### 4.3.1 Installation of Instrumentation.

a. Install instrumentation as described in Table 5, without significantly reducing the volume of, nor increasing the mass within, the crew compartment.

TABLE 5. DEFROSTER TEST RECOMMENDED INSTRUMENTATION

INSTRUMENTATION LOCATION	UNIT OF MEASUREMENT
Chamber Ambient Control	°C (°F)
Windshield Exterior Surface	°C (°F)
Defroster Vents	°C (°F)
Engine Coolant	°C (°F)
Engine Speed	rpm

b. It is recommended that the instrumentation cables be routed out of the test vehicle through a small opening that can be sealed, such as a drain plug, wire pass-through or the gunner's hatch, that can remain closed throughout testing to prevent damaging the cables. Avoid running cables through doors and windows if possible.

c. Set all defroster vents to their fully open position, with the louvers facing perpendicular to the vent surface so that the airflow is unrestricted and not diverted to be focused on any specific point of the windshield; no other louver direction may be used.

d. Clean the exterior surface of the windshield and wiper blades, using plain water and paper towels. Position the windshield exterior surface thermocouple as close to the center as possible but while remaining outside of the wiper arch. Use a tape measure to determine the exterior surface area of the windshield. Then use a graduated cylinder to measure 0.05 milliliters (ml) of de-ionized (or distilled) water per square centimeter ( $\text{cm}^2$ ) of glass area ( $0.05 \text{ ml/cm}^2 = 0.01 \text{ ounce per square inch (oz/in.}^2\text{)}$ ) and pour it into an electric spray gun (or similar).

**NOTE:** If the side door windows are included in vehicle performance specification for defroster testing, prepare the windows in the same manner as the windshield; however, the water quantity should be calculated, measured, and applied separately for each respective surface.

#### 4.3.2 Method.

a. Condition the test chamber to desired test temperature,  $-32\text{ }^{\circ}\text{C}$  ( $-25\text{ }^{\circ}\text{F}$ ) (to meet the low temperature operations of climactic design type Basic Cold (C1)), or  $-46\text{ }^{\circ}\text{C}$  ( $-50\text{ }^{\circ}\text{F}$ ) (to meet the low temperature operations of climactic design type Cold (C2)), unless alternative temperatures are stipulated in the vehicle performance specification, with all vehicle doors, hatches, ramps, and the hood opened. If a cold start test is to be performed prior to the defroster test, soak the vehicle for a minimum of 8 hours after all components have stabilized to within  $2\text{ }^{\circ}\text{C}$  ( $3.6\text{ }^{\circ}\text{F}$ ) of the test temperature to satisfy the cold start requirement of TOP 02-2-650. If a cold start test is not being performed prior to the defroster test, continue to soak the vehicle for a minimum of 4 hours after all temperature sensors have stabilized to within  $\pm 2\text{ }^{\circ}\text{C}$  ( $\pm 3.6\text{ }^{\circ}\text{F}$ ) of the test temperature to satisfy the low temperature requirement of MIL-STD-1180B<sup>6</sup>.

b. Upon completion of the temperature soak period, close all doors, hatches, ramps, and the hood. Use an anemometer to verify that the maximum wind speed measured 915 millimeters (mm) (36 inches (in.)) in front of the windshield does not exceed 8 km/hr (5 mph). Raise the wipers away from windshield surface and use an electric spray gun (or similar) to coat the front windshield with the premeasured amount of de-ionized (or distilled) water to simulate an icing condition. Adjust the spray nozzle to spray a  $250 \text{ mm} \pm 50 \text{ mm}$  ( $10 \text{ in.} \pm 2 \text{ in.}$ ) wide pattern when held perpendicular to, and 200 to 250 mm (8 to 10 in.) away from the glass. Apply evenly over the entire glass surface and allow the frost to set for 20 to 30 minutes before the engine is started (30 to 40 minutes before the defroster is started after a 10-minute engine warm-up period). Place the wipers back to their normal positions on the windshield after spraying is finished.

c. If a cold start test is to be performed prior to the defroster test, start the vehicle's engine in accordance with TOP 02-2-650. If a cold start test is not being performed prior to the defroster test, start the vehicle's engine in accordance with the appropriate TMs and manufacturer-provided procedures. If the engine fails to start on vehicle battery power, connect a regulated 24-volt power source to the slave adapter for additional start attempts.

d. Once the vehicle engine has started, engage the vehicle's high idle or tactical idle, as soon as allowable by the TM, and maintain this setting for the entire test period. Activate the windshield defroster 10 minutes after the engine start. Set the defroster controls according to the instructions in the TM to provide maximum heating performance. If the TM does not provide adequate detail, set the controls in accordance with the recommendations in Table 6.

TABLE 6. CLIMATE CONTROL SETTINGS FOR DEFROSTER PERFORMANCE TEST

CONTROL	SETTING
Windshield Defroster Power	On
Climate Control System Mode	Defrosting
Temperature Control Setting	Full Hot (red)
Output Vent Selector	Windshield Defroster
Fan Speed	Maximum
Source Air Selector	Fresh-Air

**NOTE:** If the vehicle is equipped with an electrical windshield defroster, activate it immediately after activating the coolant based system. If the defroster and heater are on separate systems, such as the defroster uses engine coolant and the heater is fuel fired, refer to the TM and vehicle performance specification for determination if it would be appropriate to activate the heater during the defroster test.

e. The operator is to then exit the vehicle and close the door, no personnel are to occupy the crew compartment during testing (an operator presence would affect the volume and mass inside of the cab, potentially alter air flow paths and distribution, in addition to introducing uncontrolled amounts of water vapor through respiration and perspiration, altering the relative humidity). The vehicle doors will not be opened until the last 5 minutes of the test period. Any test interruptions or deviations from this procedure are to be documented.

**NOTE:** If the vehicle is not equipped with a high idle or tactical idle setting, conduct the defroster test at normal engine idle speed. If the vehicle is equipped with a system that automatically increases the engine speed when the defroster is activated do not engage any other tactical idle or high idle setting manually.



f. Operate the defroster for 30 minutes to determine its capability to clear the windshield exterior surface of frost. Manually assisted scraping of frost from the windshield is not permitted. Photograph the windshield exterior surface in 5 minute intervals to document defrosting progression. During the last 5 minutes of testing the operator may briefly open the vehicle's door and activate the windshield wipers at their low speed setting to jettison any loose ice.

g. Determine the percentage of the windshield area defrosted by measuring the defrosted area in the digital photographs and divide by the total exterior surface area of the windshield. A one-piece windshield is considered defrosted if at least 90% of the exterior surface area is cleared of ice. A multi-piece windshield is considered defrosted if at least 75% of each separate windshield's exterior surface area is clear of ice.

## 5. DATA REQUIRED.

### 5.1 Air-Conditioner Performance Test.

- a. Temperature of the following, as applicable:
  - (1) Test chamber ambient.
  - (2) A/C output air vents.
  - (3) Head, hands, and feet positions of driver seat.
  - (4) Head, hands, and feet positions of passenger seat.
  - (5) Head, hands, and feet positions of rear roadside seat (if applicable).
  - (6) Head, hands, and feet positions of rear curbside seat (if applicable).
  - (7) Head, hands, and feet positions of other occupant seats (as applicable).
  - (8) Compartment enclosure wet bulb.
- b. Soak time.
- c. Radiant energy at roof position(s).
- d. Radiant energy at hood.
- e. Engine speed.
- f. A/C system refrigerant suction and discharge pressures.
- g. Chamber relative humidity.

- h. Cab interior relative humidity.
- i. Time from start of test to meeting minimum performance requirements.
- j. Solar exposure time.
- k. Photographs of instrumentation locations.
- l. Specific details of any deviations from this test procedure as written.

## 5.2 Heater Performance Test.

- a. Temperature of the following, as applicable:
  - (1) Test chamber ambient.
  - (2) Heater output air vents.
  - (3) Head, hands, and feet positions of driver seat.
  - (4) Head, hands, and feet positions of passenger seat.
  - (5) Head, hands, and feet positions of rear roadside seat (if applicable).
  - (6) Head, hands, and feet positions of rear curbside seat (if applicable).
  - (7) Head, hands, and feet positions of other occupant seats (as applicable).
  - (8) Engine coolant.
- b. Soak time.
- c. Time from start of test to meeting minimum performance requirements.
- d. Photographs of instrumentation locations.
- e. Engine speed.
- f. Specific details of any deviations from this test procedure as written.

## 5.3 Defroster Test.

- a. Temperature of the following, as applicable:
  - (1) Test chamber ambient.

- (2) Defroster output air vents.
- (3) Exterior surface of windshield.
- (4) Engine coolant.
- b. Soak time.
- c. Amount of water sprayed onto the windshield.
- d. Time from when water was sprayed onto windshield until start of defrosting.
- e. Time from start of test to meeting minimum performance requirements.
- f. Photographs of instrumentation locations.
- g. Photographs of windshield defrosting progression.
- h. Engine speed.
- i. Specific details of any deviations from this test procedure as written.

6. PRESENTATION OF DATA.

Plot data recorded during testing versus time in line chart format. A time versus temperature data plot example is presented in Figure 5.

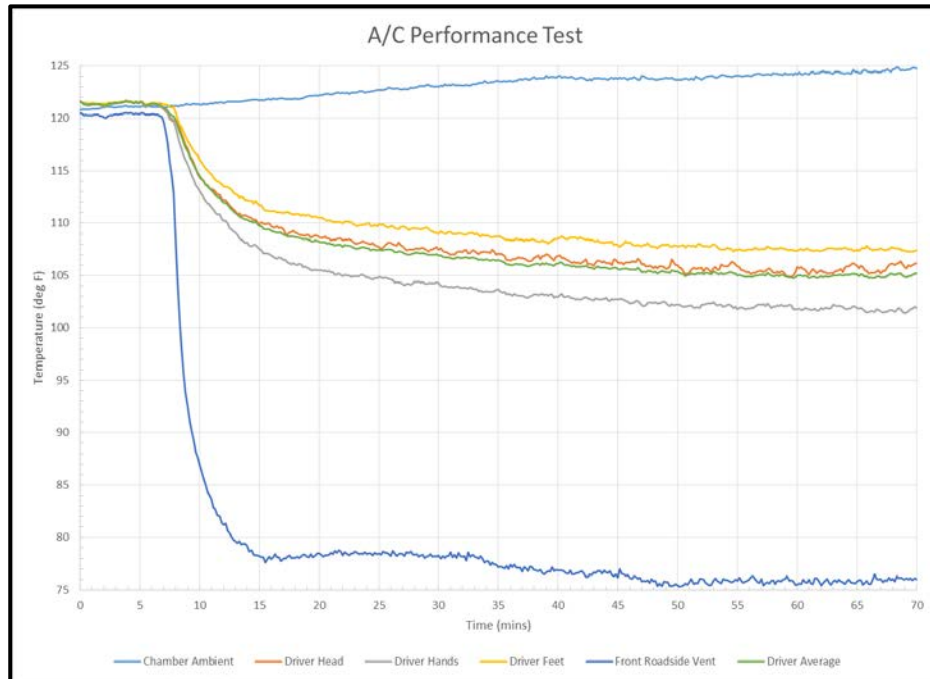


Figure 5. Example time versus temperature plot of data recorded during A/C performance testing.

APPENDIX A. CHECKLIST GUIDE FOR TACTICAL VEHICLE CLIMATE CONTROL TESTS.

ITEM	YES	NO	NA
1. Preoperational inspection and services performed on vehicle and all interior cab panels installed.			
2a. Vehicle prepared for cold weather operation, with specific attention to appropriate fuel, engine oil, and coolant mixture.			
2b. Vehicle prepared for hot weather operation, with specific attention to appropriate A/C refrigerant amounts.			
3. Manual engine coolant valves to heater core (if equipped) placed in correct position.			
4. All other items not part of vehicle inventory removed.			
5. Climate control system functional inspection completed and airflow is present at all vent locations.			
6. Vehicle positioned appropriately in chamber and exhaust ducts connected.			
7. Chamber toxic fume monitoring and 2-way voice communications devices are operational.			
8. All required instrumentation calibrated, properly installed, and operational.			
9. All vent louvers properly positioned and climate control system set to appropriate configuration.			
10. Means available to slave-start engine if necessary.			
11. Required data recorded.			
12. Safety procedures posted and followed.			
13. Appropriate personal protective equipment (PPE) and cold-weather clothing available for test personnel.			

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APPENDIX B. ABBREVIATIONS.

°C	°Celsius
°F	°Fahrenheit
A/C	air-conditioning
AR	Army Regulation
cm <sup>2</sup>	Square centimeter
FM	Field Manual
Fwb	Fahrenheit wet bulb
in.	inch
km/hr	kilometers per hour
MIL-STD	Military Standard
ml	milliliter
mm	millimeter
mph	miles per hour
oz/in. <sup>2</sup>	ounces per square inch
PPE	personal protective equipment
psi	pounds per square inch
psig	Pounds per square inch gauge
PVC	polyvinyl chloride
RH	relative humidity
rpm	revolutions per minute
SRP	seat reference point
TM	Technical Manual
TOP	Test Operations Procedure
W/m <sup>2</sup>	watt per square meter

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## APPENDIX C. REFERENCES.

1. MIL-STD-810G w/Change Notice 1, Department of Defense Test Method Standard, Environmental Engineering Considerations and Laboratory Tests, 15 April 2014.
2. TOP 02-2-505, Inspection and Preliminary Operation of Vehicles, 04 February 1987.
3. FM 9-207, Operations and Maintenance of Ordnance Materiel in Cold Weather, 20 March 1998.
4. TOP 02-2-650, Engine Cold-Starting and Warm-Up Tests, 12 February 2008.
5. MIL-STD-1472G, Department of Defense Design Criteria Standard, Human Engineering, 11 January 2012.
6. MIL-STD-1180B (Notice 1), Department of Defense Interface Standard, Safety Standards for Military Ground Vehicles, 7 August 1991.

For information only (related publications).

- a. Army Regulation (AR) 70-38, Research, Development, and Acquisition; Research, Development, Test and Evaluation of Materiel for Extreme Climatic Conditions, 15 September 1979.
- b. TOP 02-2-708, Vehicle Personnel Heater Compatibility, 18 July 1980.
- c. Society of Automotive Engineers (SAE) J381, Surface Vehicle Recommended Practice for Windshield Defrosting Systems Test Procedure and Performance Requirements-Truck, Buses, and Multipurpose Vehicles, January 2009.
- d. SAE J2646, Surface Vehicle Recommended Practice for Cab Air-Conditioning Test Procedure-Heavy Trucks with and without Sleepers.
- e. TOP 02-2-816, High and Low Temperature Tests of Vehicles, 21 March 1979.

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APPENDIX D. APPROVAL AUTHORITY.

CSTE-TM

31 March 2017

MEMORANDUM FOR

Commanders, All Test Centers  
Technical Directors, All Test Centers  
Directors, U.S. Army Evaluation Center  
Commander, U.S. Army Operational Test Command

SUBJECT: Test Operations Procedure (TOP) 02-2-820 Tactical Vehicle Climate Control Testing, Approved for Publication

1. TOP 02-2-820 Tactical Vehicle Climate Control Testing, has been reviewed by the U.S. Army Test and Evaluation Command (ATEC) Test Centers, the U.S. Army Operational Test Command, and the U.S. Army Evaluation Center. All comments received during the formal coordination period have been adjudicated by the preparing agency. The scope of the document is as follows:

This TOP provides procedures for determining the maximum performance climate control capability of tactical vehicles in a minimalist baseline configuration inside of a climactic test chamber.

2. This document is approved for publication and will be posted to the Reference Library of the ATEC Vision Digital Library System (VDLS). The VDLS website can be accessed at <https://vdls.atc.army.mil/>.

3. Comments, suggestions, or questions on this document should be addressed to U.S. Army Test and Evaluation Command (CSTE-TM), 2202 Aberdeen Boulevard-Third Floor, Aberdeen Proving Ground, MD 21005-5001; or e-mailed to [usarmy.apg.atec.mbx.atec-standards@mail.mil](mailto:usarmy.apg.atec.mbx.atec-standards@mail.mil).

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Forward comments, recommended changes, or any pertinent data which may be of use in improving this publication to the following address: Policy and Standardization Division (CSTE-TM), US Army Test and Evaluation Command, 2202 Aberdeen Boulevard, Aberdeen Proving Ground, Maryland 21005-5001. Technical information may be obtained from the preparing activity: Automotive Directorate (TEDT-AT-AD), U.S. Army Aberdeen Test Center, 400 Colleran Road, Aberdeen Proving Ground, Maryland 21005-5059. Additional copies can be requested through the following website: <http://www.atec.army.mil/publications/topsindex.aspx>, or through the Defense Technical Information Center, 8725 John J. Kingman Rd., STE 0944, Fort Belvoir, VA 22060-6218. This document is identified by the accession number (AD No.) printed on the first page.